

1 Description

2

3 Optical Module And Optical System

4

5 The invention relates to an optical module comprising a
6 circuit carrier, a cased semiconductor element placed on the
7 circuit carrier and a lens unit for projecting
8 electromagnetic radiation onto the semiconductor element.

9

10 The invention also relates to an optical system with an
11 optical module formed in the same way.

12

13 Generic optical modules and systems are particularly
14 applicable to automotive engineering.

15

16 Such applications can make use of electromagnetic radiation
17 in different frequency ranges, so that in addition to visible
18 light, which is typically used by applications dealing with
19 the space surrounding a motor vehicle, such as lane departure
20 warning (LDW), blind spot detection (BSD) or rear view
21 cameras, use is also made of the invisible infrared radiation
22 which is preferred in applications within a motor vehicle,
23 such as out of position detection (OOP) or, subject to
24 additional external illumination, a night vision system.

25

26 Because of external influences such as temperature, humidity,
27 contamination and vibration, stringent requirements are
28 placed on applications relating to the interior or exterior
29 of motor vehicles. The typical service life of systems in
30 vehicles is between 10 and 15 years, during which time only
31 extremely low failure rates are tolerated; the components of
32 an optical system of the type mentioned at the outset must
33 therefore also exhibit only very slow deterioration.

1
2 In many cases the space available for installing optical
3 modules or optical systems is very limited, and represents
4 further difficulties for the production of optical systems.
5 Using conventional means it is therefore extremely difficult
6 to construct a reliable, hermetically sealed unit from a
7 camera chip (CCD or CMOS sensor) and an optical system.

8
9 In order to obtain adequate image definition for a camera
10 system consisting of an image sensor (currently CCD or CMOS)
11 and a lens system, the geometry of the sensor and optics must
12 be very precisely matched. The tolerance range for the
13 distance between the camera chip and the optics in the Z axis
14 is usually a few hundredths of a millimeter in order to
15 obtain an optimally sharp image for a given depth of field
16 range. This is a particular problem for those systems known
17 as fixed focus, since during manufacture they are burdened
18 with tolerances which are small at best. A misalignment
19 between the camera chip and the optics along the X or Y axis
20 can also result in making the optical system "squint", that
21 is, the image is cut off at one edge (horizontally or
22 vertically), because the offset means there are no more
23 pixels available at this position and they should to be
24 provided as a precaution.

25
26 A further problem is known as "tilt", in which the camera
27 chip tilts about the X or Y axis; as a result the image has a
28 blurred gradient in the horizontal or vertical direction.
29 There can also be rotation about the Z axis between the
30 camera chip and the optics.

31
32 Virtually all fixed focus camera systems that are
33 commercially available at the present time require an

1 additional matching step during manufacture; this involves
2 setting the distance between the camera chip and the optics
3 along the Z axis and then fixing it at that value. This may
4 be done with the aid of a screw thread and a corresponding
5 set screw or an adhesive joint. A matching step may also be
6 needed for the X-Y misalignment or, if this is not done, a
7 correspondingly larger sensor may be provided in order to
8 satisfy the tolerances by means of an increased number of
9 pixels. It is also known that rotation can be excluded or
10 calibrated by means of software. Since otherwise sharp image
11 information exists, the pixels need only be reallocated in a
12 type of adjustment process. However, there may be simply no
13 information at the edges or corners, because they have been
14 cut off. In most systems, a purely mechanical reduction of
15 the tilt and rotation between the chip and the optics can
16 usually only be achieved by high-precision manufacturing and
17 assembly or by component matching.

18

19 However, due to costs and quality assurance aspects, cameras
20 for specific low cost applications such as automotive and
21 industrial, digital cameras, mobile phones, toys etc., must
22 be capable of being manufactured as far as possible without
23 adjustment processes between the optics and the camera chip,
24 that is, without setting the focus to the optical surface of
25 the CMOS or CCD sensor. This runs basically counter to the
26 requirements mentioned above.

27

28 One option for developing a focus-free system is to reduce
29 the total number of possible tolerances and elements, so that
30 the module or system is designed to operate without
31 adjustment at least within defined ranges of distance and
32 temperature. When for example the invention is used in the
33 context of a vehicle occupant protection system, to which

1 however the present invention is not restricted, clearly
2 defined images should be guaranteed at distances of 15 cm to
3 130 cm, for instance, and at temperatures between -40°C and
4 +105°C. The fewer the elements in the tolerance chain, the
5 more feasible this becomes. In housed semiconductor elements,
6 the necessary soldered or adhesive joints or the like between
7 the chip and the circuit carrier occupy a particularly large
8 part of the tolerance chain.

9
10 When only one lens is used, steps are taken to avoid
11 complicating the lens configuration in order not to produce
12 additional optical tolerances. The actual lens holder,
13 preferably made of plastic, can be connected to the lens
14 assembly by different means, so that an exact optical
15 alignment of the lens assembly and the semiconductor element
16 can always be ensured relative to the lens holder or the lens
17 assembly.

18
19 Even so, in systems having a fully conventional structure for
20 the objective and camera chip, in which the camera chip or
21 the semiconductor element is arranged on a suitable circuit
22 carrier within a case, it is difficult to fully solve the
23 above-mentioned problems at the same time as fulfilling the
24 said quality requirements. As it happens, for cased
25 semiconductor chips, special measures against parasitic light
26 radiation or other environmental influences need only be
27 taken from the front, since the chip housing provides
28 adequate protection from the back for the silicon, which is
29 transparent to infrared radiation. The objective itself,
30 however, must be adjusted to the camera chip and possess
31 defined focusing. Nowadays this process uses a tolerance-
32 laden locking device such as a screw fitting, an adhesive or

1 the like, which fixes the objective relative to the camera
2 chip and circuit carrier.

3
4 The object of the invention is to provide an optical module
5 and an optical system comprising a cased semiconductor
6 element arranged on a circuit carrier, with the aim of
7 reducing the possible tolerance chain to an absolute minimum,
8 so that by means of simple and cost-effective assembly it is
9 possible to produce reliable optical quality which does not
10 need costly adjustment and in particular focusing, and will
11 last for the service life of the module or system. It is
12 further intended as far as possible to omit measures against
13 parasitic light radiation or other environmental influences
14 from the front.

15
16 This object is achieved by means of the features which will
17 emerge from the main claims. Advantageous embodiments of the
18 invention, which can be used individually or in combination
19 with one another, are specified in the sub-claims.

20
21 The invention is based on a generic optical module in which
22 the lens unit for projecting electromagnetic radiation onto
23 the semiconductor element comprises a type of lens holder
24 that is an integral component of the case (housing) of the
25 semiconductor element. This can be produced easily by using
26 injection-molded plastic housings, since in this event, in
27 addition to the actual shape of the case, the edge area in
28 particular can take virtually any form, and in particular can
29 include an area for supporting a lens assembly with a defined
30 focus in relation to the chip. By this means a cased chip can
31 initially be manufactured as a standard component in the form
32 of a surface mounted device (SMD) already provided with a
33 mounting to receive the optics which will be fitted later.

1 The tolerance range available for focusing is then
2 essentially dependent only on the lens assembly. The proposed
3 solution has the further advantage that the integrated design
4 of the lens holder and the chip case eliminates the incidence
5 of parasitic light from the side.

6
7 In a preferred embodiment of the invention the area
8 supporting the lenses is formed in one piece with the
9 housing, for example out of a thermosetting plastic material.

10
11 Alternatively, the area supporting the lenses is preferably
12 formed on the housing, for instance in a two-component
13 injection process. This advantageously enables the optional
14 use of different plastics. For example it has been found
15 useful to form the area supporting the lenses from a
16 thermoplastic material and the housing for the semiconductor
17 housing from a thermosetting plastic material.

18
19 The major difference between heat-formable thermoplastic and
20 thermosetting plastic, which is not heat-formable, is based
21 on the behavior of the plastic concerned during forming. When
22 a thermoplastic is heated and pressed into a mold, no
23 chemical reaction of any kind takes place. Once the plastic
24 in the mold has cooled and hardened, it could be reheated and
25 made into another shape without any noticeable change
26 occurring in the characteristics of the plastic. This
27 property can be put to advantageous use in the case of the
28 connection configurations described in a later section and
29 consisting of at least one lens together with supporting
30 area.

31
32 Thermosetting plastics on the other hand undergo chemical
33 changes while being given their final shape. They react with

1 a condensation polymerization and bond together in the form
2 of a three-dimensional lattice. This hardening by means of a
3 structural change in the molecule is particularly
4 advantageous with respect to fixing the leadframe of a
5 semiconductor element and is not reversible: Once a
6 thermosetting plastic has been formed, its shape cannot be
7 changed. Thermosetting plastics include phenolic resins,
8 melamines and urea resins.

9
10 A lens assembly is preferably provided with a plurality of
11 lenses and optionally at least one diaphragm in the form of a
12 package. The optical quality can be improved by an objective
13 having a plurality of lenses, which is also possible in the
14 context of the present invention, particularly since it is
15 then possible to operate using few tolerances. In this
16 connection it is also particularly advantageous for the
17 lenses and where appropriate the diaphragm to be in direct
18 contact with one another. This approach virtually excludes
19 fluctuations of the lens assembly in the Z direction, that
20 is, in the same direction as the sequence of lenses. The
21 tolerances are then dependent only on the lens assembly
22 itself. Similarly it is particularly useful for the relative
23 positions of the lenses to be matched to one another by the
24 geometry of the actual lenses and, as appropriate,
25 diaphragms. The arrangement of the lenses can also be defined
26 by the lenses themselves in the X-Y direction, in this case
27 by appropriately designing the bearing surfaces of the lenses
28 or diaphragms.

29
30 It is particularly useful for exactly one of the lenses or
31 diaphragms to be in direct contact with the lens holder.
32 Since the lenses determine their positions relative to one
33 another, it is sufficient to attach just one lens or

1 diaphragm to the lens holder. By this means the whole lens
2 assembly is aligned relative to the semiconductor element, so
3 that the advantageous optical quality can finally be
4 guaranteed. In this connection it is particularly
5 advantageous if the exactly one lens is joined to the lens
6 holder in a watertight and dustproof manner. Advantageously
7 the front lens is chosen as the lens which works in
8 conjunction with the lens holder to provide a seal. The
9 methods for attaching the exactly one lens to the lens holder
10 can include ultrasound, laser soldering and/or adhesives;
11 alternatively or cumulatively, screws and/or mastic or the
12 like may be used in appropriate cases.

13
14 Similarly it is possible to use a means of latching so that
15 the lens assembly can be snapped into the area supporting the
16 lenses. Moreover this makes it possible to ensure exact
17 positioning. It must be further emphasized that by this means
18 it is easier to ensure that the lenses are kept separate from
19 the other components, in particular the expensive
20 semiconductor element. The sealing effect is provided in
21 conjunction with a snap assembly in a particularly
22 advantageous way, in that the lenses have a hard and a soft
23 component, the soft component being arranged as a seal in the
24 area of the lenses. The soft component also supports the
25 general requirement that when the assembly is snapped in,
26 care must be taken not to introduce stress into the lenses;
27 stresses would always have a negative effect on the optical
28 properties.

29
30 As an alternative to an adhesive or soldered joint, or to a
31 snap assembly, a specially designed retaining element (molded
32 ring) can be provided for attaching the lens assembly in the
33 area supporting the lenses. The retaining element preferably

1 has a hard component and a component of which at least some
2 section is permanently elastic. A permanently elastic
3 component which is preferably designed as a ring can also
4 seal the lens assembly against humidity and contamination, in
5 addition to its intrinsic function of compensating for any
6 mechanically and/or thermally induced stresses. The
7 permanently elastic component is preferably formed on the
8 area supporting the lenses. In the area of the harder
9 component the retaining element is arranged on the area
10 supporting the lenses by means of an attachment method which
11 can be automated, such as ultrasound, laser soldering,
12 adhesive, riveting, forming or some other equally effective
13 automated method. Screwed or snap joints are also possible.
14 The hard component of the retaining ring preferably contains
15 a thermoplastic material. A permanently elastic component
16 which preferably contains thermoplastic elastomer (TPE),
17 silicon or the like has proved to be useful in this respect.
18 For the purpose of providing a component which can be
19 uniformly and easily handled, it is preferable for the
20 permanently elastic component to be formed on the hard
21 component, or vice versa, in a two-component injection
22 process.

23
24 It can further be particularly advantageous to prevent
25 unwanted optical effects, in particular those due to lateral
26 light incidence, by means of a black and/or dull finish or by
27 the use of total reflection, achieved by applying the
28 appropriate pigments to the area supporting the lenses. These
29 are examples of appropriate measures.

30
31 The invention further consists of an optical system with an
32 optical module of the type mentioned above. The optical

1 module then shows to its best advantage in the context of an
2 overall system.

3
4 The invention is based on the recognition that by designing a
5 chip housing with an integrated area supporting the lenses, a
6 chip can be fitted by means of SMD technology prior to
7 assembling said lenses and a camera module can be
8 incorporated when the lenses are assembled, thereby making it
9 unnecessary to set the focus mechanically. Thus manufacture
10 of the module can be fully automated, with the advantage that
11 manufacturing and assembly costs are lower for large
12 quantities. Furthermore the optical module can be produced
13 without moving parts such as screw threads or fixing screws,
14 resulting in greater reliability. Since the configuration has
15 few tolerances in both the X axis and the Y axis, the chip
16 need not be unnecessarily large in area, which reduces the
17 cost of the camera chip. The design of such a module can be
18 relatively compact, with the advantage that the camera module
19 can even be used in applications where the available space is
20 limited. Lastly, the integrated design provides the
21 additional advantage of protection against parasitic light
22 radiation.

23
24 The invention can be put to good use in the production of
25 video systems, possibly in combination with radar systems,
26 ultrasound systems and the like in the automotive sector.

27
28 The invention is now described by way of example with regard
29 to the accompanying drawings with reference to preferred
30 exemplary embodiments, in which;

31
32 Fig.1 shows a view of the optical module to which the
33 invention relates, shown in perspective; and

Fig. 2 shows the module according to Fig.1 shown as a sectional view along the line A-A.

In the description which follows of preferred embodiments of the present invention the same reference numbers designate the same or comparable components.

Fig.1 shows in perspective a view of an optical module to which the invention relates, comprising: a circuit carrier 10; a semiconductor element 12 housed using SMD technology and arranged on the circuit carrier 10, and a lens unit 14; 16, 18, 20; 21 for projecting electromagnetic radiation onto the semiconductor element 12.

Fig. 2 shows the module according to Fig.1 as a sectional view along the line A-A.

According to the invention the lens unit comprises a lens holder 14 that is an integral component of the housing 13 of the semiconductor element 12. In the present exemplary embodiment the area 14 supporting the lenses is preferably formed in one piece with the housing 13 from for example a dual-plastic material that is typically used for chip housings and has proved particularly advantageous for an adhesive, screwed and/or snap fixing between a lens 20 held in the area 14 and said area 14. An alternative possibility is a formed connection between the housing 13 and the area 14 supporting the lens assembly 16, 18, 20; 21.

The semiconductor element 12 can be designed according to present-day technology, for instance as CMOS or CCD. The housed (encased) semiconductor element 12 and the circuit

1 carrier 10 are connected by means of elements known as
2 leadframes 30, which are in contact via gold wires 28 with
3 bonding points (not shown) formed on the semiconductor chip
4 12. To protect the solder points between leadframes 30 and
5 circuit carriers 10 from breaks in contact, for example due
6 to mechanical stresses, the case 13 of the chip 12 is
7 preferably also joined to the circuit carrier 10 by adhesive.
8 An adhesive for this purpose could be that used for SMD
9 applications or similar.

10
11 The circuit carrier 10 itself is preferably in the form of a
12 rigid PCB. The said 10 can be electrically connected via
13 ribbon cable to further rigid circuit boards (not shown). It
14 is advantageously possible to do without a separate
15 electrical connection of this type by using a flexible
16 printed circuit board as the circuit carrier 10 which at the
17 same time provides the electrical connections (not shown),
18 possibly by means of soldering. Due to their angle and
19 position etc., such rigid-flexible systems, as they are
20 known, are a particularly flexible solution for connecting
21 the circuit carrier 10 or module to a control unit or circuit
22 board (not shown).

23
24 Three lenses 16, 18, 20 and one diaphragm 21 are preferably
25 used in the area 14 supporting the lenses, within the chip
26 housing 13, for applications inside a motor vehicle interior.
27 The lenses 16, 18, 20 and the diaphragm 21, are formed so
28 that they occupy a defined position relative to one another
29 in the area 14 supporting the lenses, within the chip housing
30 13. At least one of the lenses 16 is further designed to work
31 in conjunction with the area 14 supporting the lenses, in
32 such a way that the said 16 occupies a defined position
33 relative to an electromagnetic radiation-sensitive surface 34

1 of the semiconductor element 12. Moreover at least one lens
2 20 is joined to the holder 14 in a watertight and dustproof
3 manner, for example by a means of latching 32. All lenses 16,
4 18, 20 and where appropriate diaphragms 21 are thus aligned
5 relative to the semiconductor element 12. Said alignment is
6 unaffected by further measures, since the area 14 supporting
7 the lenses 16, 18, 20; 21 is an integral part of the
8 semiconductor housing 13.

9
10 Since the chip housing 13 is designed to have an integrated
11 area 14 supporting the lenses 16; 18, 20; 21, the present
12 invention can incorporate a camera module in which a chip 12,
13 13 can be fitted by means of SMD technology prior to
14 assembling the lenses 16, 18, 20; 21, and when the lenses 16,
15 18, 20; 21 are being assembled any kind of mechanical focus
16 setting can be dispensed with. Thus manufacture of the module
17 can be fully automated, with the advantage that manufacturing
18 and assembly costs are lower for large quantities.
19 Furthermore the module can be produced without moving parts
20 such as screw threads or fixing screws, resulting in greater
21 reliability. Since the configuration 13; 14; 16, 18, 20; 21
22 has few tolerances in both the X axis and the Y axis, the
23 chip area 34 need not be unnecessarily large, which reduces
24 the cost of the camera chip 12. The design of such a module
25 can be very compact, with the advantage that the camera
26 module can even be used in applications with limited space
27 available. The configuration further offers the possibility
28 of designing a hermetically sealed module which is well
29 protected against environmental influences such as humidity,
30 dust and the like.

31
32 The features of the invention disclosed in this description,
33 in the drawings and in the claims can be significant, both

1 individually and in any combination, for the accomplishment
2 of the invention. It is particularly suitable for
3 applications relating to the interior and/or exterior of
4 motor vehicles.

5